Morphological diversification of competitors training Greco-Roman style of wrestling

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

Władysław Jagiełło[1ABCDE], **Artur Kruszewski**[2BCD]

[1] Jędrzej Śniadecki Academy of Physical Education and Sport in Gdańsk, Gdańsk, Poland
[2] Józef Piłsudski Academy of Physical Education in Warsaw, Warsaw, Poland

Abstract

Background and Study Aim:
The internal proportions of body build of a specific sportsman or chosen athletes' group is very important and little know problem of sport anthropology.

That issue is extremely current in combat sports and particularly in wrestling. Cognitive purpose of the research is an attempt of defining qualification of propriety of body build of national Polish representatives in training Greco-Roman style of wrestling against the background of persons of the same population who do not practice sport professionally.

Material/Methods:
The research included the representatives of Poland in Greco-Roman wrestling (n=13). Age of the competitors ranged from 18–28 years (20.54±2.60), mass of body ranged 53–120 kg (78.23±20.72) and height 162–191 cm (173.99±10.71). The length of training time of wrestlers was 5–12 years (8.54±2.22) and was considerably varied. The comparative group were the students of Warsaw Technical University (Poland). 20 basic somatic measurements were conducted according to the accepted rules. There were specified some indices: slenderness, Rohrer, BMI, Manouvrier and pelvis – shoulder. Densities of body, total fat of body, active tissue, general profile of body build, internal proportions of body build were calculated.

Results:
The analysis of internal proportions of competitors' body build factors revealed essential differences of individual set of features. Predominant among distinguished three factors in light and middle weight categories is factor of fat deposition and in a heavy weight category is factor of fat deposition and stoutness. Proportions of internal features of the factors showed that in all weight categories particularly strongly muscled is forearm, on the contrary – weakly – shin. within features expressing stoutness of skeleton, only within light and middle weight categories wrestlers occurs distinct predominance of elbow width and no proportionate – with reference to general factor value – small pelvis width.

Conclusions:
The important factor determining morphological differentiation of wrestlers are weight categories. The bigger the body mass the more distinct becomes change of body build into direction of body mass gain at the cost of loss of slenderness features.

Key words:
body build • Greco-Roman wrestling • national team

Author's address:
Władysław Jagiełło, Academy of Physical Education and Sport in Gdańsk, Wiejska 1 Str., 80-336 Gdańsk, Poland, e-mail: wjagiello1@wp.pl

Body builds – constitution of the human body.

BACKGROUND

The anthropologists current research confirm the fact, that body build is one of the elements distinguishing athletes from persons who do not practice sport systematically [1–3]. Within sportsmen representing different disciplines, it is also confirmed that there are essential differences in their body build [4,5].

Numerous scientific research in this range is oriented on finding dependence between different aspects of body build and the level of sports championship or efficien-

Greco-Roman wrestling
– style of wrestling that prohibits the legs from being used to obtain a fall and in which no holds may be taken below the waist, the style practiced exclusively in Olympic and international amateur competition,

National team – is group of competitors together representing a nation in a sport.

cy of a sport fight. Such results are available in judo [6], freestyle wrestling and **Greco-Roman wrestling** [7,8], fencing [9] and tennis [10,11].

Important course of scientific research on subject of sportsmen' body build is the aspect of their development [12,13] as well as their propriety with reference to persons who do not practice sport systematically [14,15]. The basis of that type of research is analysis so called somatotypes, and components or proportions of tissue. The internal proportions of body build of a specific sportsman or chosen athletes' group is very important and little know problem of sport anthropology. That issue is especially current in combat sports and particularly in wrestling.

In connation with that, the main cognitive aim of our research is an attempt of determining morphological differentiation of representatives of Poland in wrestling (Greco-Roman style), with regard to weight categories and solving the following questions:
- What somatic features determine specific body build of wrestlers?
- What internal proportions of body build are characteristic for them?

METHODS

Anthropometrical measurements were conducted according to accepted rules [1], using standard instruments. Moreover, five indices were specified: slenderness, Rohrer, Quetelet II, Manouvrier and pelvis – shoulder.

Total body fat in the percentage of body mass was calculated according to equation of Brożek and Keys [16]. Densities of body were calculated on the basis of subdermic fat measurements by means of predicting of Piechaczek [17]. All in all 20 basic somatic measurements were taken.

Profiles of body build of male wrestlers were conducted by the method of standardization of features. The comparative group was constituted by the students of Warsaw Technical University [18].

Evaluation of internal proportions of body build was conducted by the method of natural indices by Perkal [19] with modifications by Milicerowa [20]. With this end in view the following was determined: factors of build (m), index of general size of the body (M), internal proportions of body build (natural indices for each factor of build), uniformity of build (index of inter individual variation), code of internal proportions of the group (point scale of natural indices by Perkal), internal proportions of features of build within each of the factors.

In the result of literature analysis and practical experience in training of the best wrestlers in the world, wrestlers were divided into three conventional weight categories: light (54–66 kg), middleweight (74–84 kg), heavyweight (96–120 kg) [21,22]. Results of the research underwent basic statistical analysis and arithmetical mean (X) was evaluated as well as standard error (±SD), variation coefficient (V%), correlation coefficient and relevance of differences (test t).

MATERIAL

The research included the representatives of Poland in Greco-Roman wrestling (n=13). Anthropometrical measurements were conducted during grouping of the national wrestling team (COS – Spała on 25–26 May 2004.). Age of the competitors ranged from 18–28 years (20.54±2.60), mass of the body ranged from 53–120 kg (78.23±20.72) and height 162–191 cm (173.99±10.71). The length of training time of wrestlers was 5–12 years (8.54±2.22) and was considerably varied (V%=26.20).

RESULTS

Body build of representatives of Poland in wrestling is varied depending on represented weight category. From chosen twenty somatic features of wrestlers essential differentiates with reference to comparative group were revealed: in 17 features in light categories, 15 in middle categories and 18 – in heavy (Table 1).

Profiles of body build of Polish **national team** of wrestling within three traditional weight categories are presented by Figure 1. Direct measurements of body of competitors go up alongside weight categories, what is natural phenomenon. Differences among competitors and the control group however, not in all cases appear with the same intensity.

From among all weight categories, competitors of heavyweight categories get distinguished mostly by generally bigger build (height, mass and body surface) both with reference to other competitors and to the comparative group. What is worth noticing in their forearm diameter – and in this respect they outgrow their friends from middle weight categories by 2.07 standardized value (Z) and those who do not train by 3.70 Z as well as shin diameter – difference from competitors of middle weight categories is 2.34 Z. Characteristic feature in their build is also quite significant elbow, knee and pelvis outgrowing analogical for competitors of middle weight categories indicators, relevantly by 1.69 Z, 1.94 Z and 2.77 Z and with reference to non training students by 2.04 Z, 1.90 Z and 1.80 Z. Taking into con-

Table 1. Body build features of representatives of Poland in Greco-Roman style of wrestling in various weight categories and students of Warsaw Technical University and evaluation of relevance of differences n=13.

Somatic features	Students, n=165		Weight categories								
			Light: 54–66 kg, n=5			Middle: 74–84 kg, n=4			Heavy: 96–120 kg, n=4		
	X	SD	X	SD	t	X	SD	t	X	SD	t
Mass of the body	72.11	8.96	59.200	5.541	−7.650***	75.500	4.435	2.397*	104.75	10.243	11.158***
Body height	179.36	6.19	163.48	1.988	−21.686***	174.18	6.002	−2.992**	186.95	3.073	7.752***
Body height in sitting posture	93.86	3.06	86.160	2.143	−12.025***	91.875	1.387	−4.388***	96.700	4.065	2.464*
Length of upper limb	78.3	3.51	73.880	1.551	−8.671***	75.675	3.986	−2.305*	84.300	0.927	15.989***
Length of Lower limb	85.5	4.1	77.320	2.151	−12.090***	82.300	4.643	−2.412*	90.250	1.358	9.623***
Shoulders width	40.67	1.59	37.540	1.256	−8.465***	40.825	1.871	0.290	43.175	1.903	4.620***
Pelvis width	28.44	1.46	25.520	1.119	−8.835***	27.025	0.842	−5.448***	31.075	1.609	5.722***
Elbow width	6.98	0.34	6.580	0.110	−9.927***	7.100	0.455	0.931	7.675	0.275	8.598***
Knee width	9.82	0.45	8.900	0.510	−6.315***	9.800	0.356	−0.191	10.675	0.457	6.497***
Forearm diameter	26.02	1.8	26.120	1.052	0.309	28.950	1.320	7.473***	32.675	1.300	17.208***
Shin diameter	36.86	2.3	33.460	2.024	−5.769***	36.875	1.181	0.040	42.250	1.936	9.520***
Body density	1.058	0.007	1.060	0.003	2.518**	1.052	0.008	−2.497*	1.047	0.010	−4.072***
Fat, %	15.66	2.74	14.910	0.988	−2.160*	18.049	3.209	2.610**	20.018	3.719	4.138***
Active tissue,%	84.34	2.74	85.090	0.988	2.160*	81.951	3.209	−2.610**	79.982	3.719	−4.138***
Body surface	1.9015	0.125	1.984	0.032	6.289***	2.115	0.052	12.255***	2.248	0.065	16.840***
Indicato of slenderness	43.21	1.66	42.576	0.930	−2.197*	41.819	1.119	−4.137***	40.337	1.374	−7.137***
Rohrer indicator	1.25	0.15	1.353	0.088	3.784**	1.432	0.113	5.431***	1.605	0.171	7.281***
BMI indicator	22.4	2.46	22.124	1.634	−0.560	24.906	1.401	5.785***	29.986	3.034	8.790***
Manouvrier indicator	91.0931	2.82	89.813	4.195	−1.081	89.538	3.731	−1.470	93.494	5.297	1.617
Shoulder-pelvis indicator	69.9287	2.4	68.061	4.176	−1.592*	66.253	2.222	−5.707***	72.089	4.976	1.551

* p<0,05 ** p<0,01 *** p<0,001

sideration proportion of body mass to height – on the basis of so called indicators – those competitors represent strong type of build (according to slenderness indicator), defined as stout (acc. to Rohrer indicator) and significant overweight (BMI). Beside the competitors of heavy weight categories are classified as long-legged (acc. to Manouvrier indicator) with middle intensification male type of build (pelvis – shoulder indicator). Small body density is also worth noticing (–0.74) Z with reference to competitors of middle weight categories and –1.59 Z with reference to non training) connected with high fat deposition of competitors of heavy weight categories reaching 20% of body mass.

Body build of competitors of middle weight categories is mostly similar to the comparative group – average value 20 normalized features Z is –0.19. The biggest differ-

ences in the body build of competitors of middle weight categories with reference to representatives of light categories concern shoulders width – difference 2.07 Z (with reference to non training students 0.10 Z), knee width – difference 2.00 Z (with reference to non training students –0.04 Z), and sitting body height – difference 1.87 Z (with reference to non training students –0.65 Z).

Wrestlers of middle weight categories represent the strong type of build (acc. to slenderness indicator) or defined as athletic (acc. to Rohrer indicator) and proper body mass (BMI). Moreover, competitors of middle weight categories are classified as long-legged (according to Manouvrier indicator) with outstandingly male type of build (pelvis – shoulder indicator). They are characterized, with reference to competitors of light weight categories as well as non training students, by
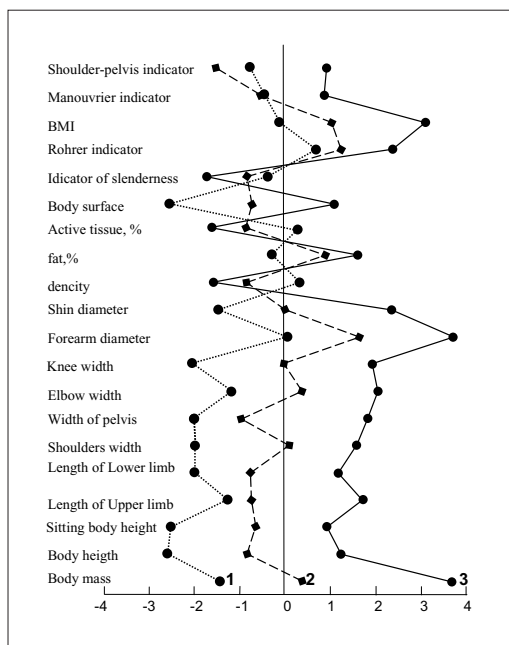
Figure 1. Profiles of body build of representatives of Poland in Greco-Roman wrestling, n=13. Designating weight categories: 1 – light (54–66 kg), 2 – middle (74–84 kg), 3 – heavy (96–120 kg).

definitely lower values of body density, relevantly by 1.18 Z and 0.86 Z.

Competitors of light weight categories are characterized generally by the smallest body build (average value 20 normalized features Z is –1.08). The characteristic feature in their body build is definitely lower value, with reference to comparative group, body height –2.57 Z, knee width –2.04 Z, length of lower limb –2.00 Z and shoulder width –1.97 Z.

They represent medium type of body build (acc. slenderness indicator) or defined as athletic (according to Rohrer indicator) and correct mass (according to BMI). Wrestlers of light categories are classified as medium length limbed (acc. to Manouvrier indicator) with strong stress on male body build (acc. to pelvis – shoulder).

The analysis conducted in this way shows general profile of build of wrestlers in three pre-arranged weight categories with reference to comparative group, however it

brought little information about internal proportions of these groups. In order to define these proportions, method of natural indicators by Perkal [20] was introduced, modified by Milicerowa [18] The values of factors of build confirm in more generalized way observations conducted on normalized values of isolated features (Table 2).

Among the distinguished three factors in light and middle categories, factor of fat deposition is dominating and in heavy – factor of fat deposition and factor of stoutness (skeleton and musculature).

Wrestlers of light weight categories are characterized by generally smaller body size comparing to the reference group (M=–1.32). Low value of factor of length(m1=–2.08) is definitely outstanding factor of this weight category. The factor of stoutness is also smaller (m2=–1.44). Only the factor of fat deposition is similar in its value to control group.

The competitors of middle weight categories are characterized by the most similar values of factors and general body size (M=0.13). Wrestlers of this group differ mostly from comparative group by fat deposition (m3=0.96) and length features (m1=–0.75). Other factors are similar in both groups.

The wrestlers of heavy weight categories differ from comparative group significantly by bigger body sizes (M=1.8). The factors that distinguish this group in the outstanding way is stoutness factor (m2=2.23) and fat deposition factor (m3=1.91). Length factor is also quite considerable (m1=1.26).

By analyzing mutual proportions among factors of body build of wrestlers of various weight categories, big differences of particular groups of body build features are revealed (Figure 2). From among three weight categories the most proportionally built are wrestlers of light categories. Value of indicator of intergroup variability is 0.65. All elements of this build have proportional contribution.

Wrestlers of middle weight categories are distinguished from among all competitors by the greatest specificity

Table 2. Factors of body build.

Factor	Weight categories		
	Light	Middle	Semi heavy and heavy
Length m1	–2.08	–0.75	1.26
Stoutness m2	–1.44	0.18	2.23
FAT deposition m3	–0.45	0.96	1.91
Idicator of general value M	–1.32	0.13	1.8

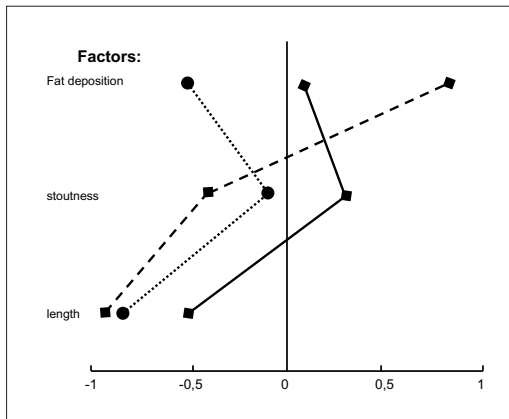**Figure 2.** Natural indicators of factors of body build of Polish wrestling national team, n=13. Designation of weight categories at Figure 1.

Figure 3. Natural indicators of somatic features within factors of Polish representatives in Greco-Roman wrestling, n = 13. Designation of weight categories as at Figure 1.

of body build (indicator of changeability within group equals 1.71). Measurements features and fat deposition are the most diverse.

Wrestlers of heavy weight categories are characterized by changeability within group (0.97). Measurement features and stoutness are the most diverse to general body size. Fat deposition is the most proportionate element in general body size (0.11).

Using point scale of natural indicators, codes of internal proportions of three weight categories of wrestlers were achieved. Code of internal proportions of build of light category wrestlers carries value 2-4-3. That means, that general body size (M) is caused by smaller than average body length, average of stoutness and smaller than average of fat deposition. Code of internal proportions of middle weight categories wrestlers is expressed by the following values: 2-4-6, and heavy – 3-5-4.

Measurements of internal proportions of features of build within every factor are the source of very important information on body build of wrestlers. In all weight categories forearm is particularly strongly muscular, while the shin very little (Figure 3). Within features expressing stoutness of skeleton only within light weight category competitors occurs distinct predominance of elbow width and no proportionate – with reference to general factor value – small pelvis and shoulder width. Within middle weight categories, features expressing stoutness of skeleton are more proportionate (except very small pelvis width). Within heavy weight categories stoutness of skeleton is smaller than stoutness of musculature. It appears predominance of elbow width over other features of stoutness of skeleton. Length factor in all weight categories is varied the least. The only predominance of upper limb length (particularly in heavy weight categories) over lower limb and body height occurs.
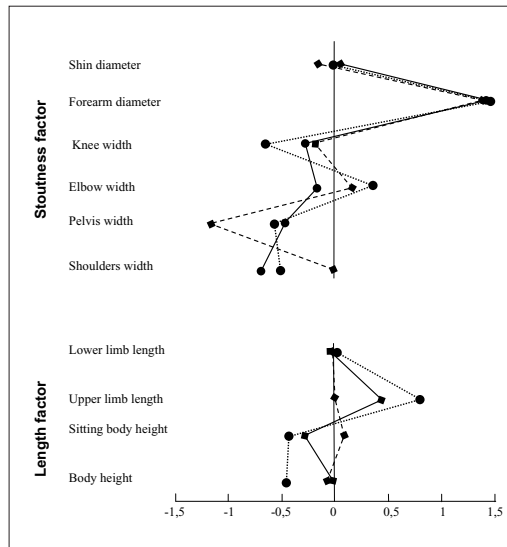
Discussion

Morphological diversification of wrestlers revealed in the result of research constitutes the resultant of two processes. On one side – process of sport selection and on the other side – effect of adaptation of organism to external factors that influence it. Wrestlers, similarly as weight – lifters are numbered to strong men's category, what is observed in their somatic features.

Scientific research of Marchocka and Skibińska show that wrestlers are characterized – with reference to body height – by short legs and tendency to longer upper limbs. They have got bigger tendency to relative superiority of shin width over pelvis width. Elbows of wrestlers were quite much massive than knees. The biggest differentiation is within body diameter. Particularly arms and forearms of wrestlers are strongly muscled, while shin and pelvis – relatively the least. Our research only partly confirms the authors observations. The representatives of Poland in Greco-Roman style of wrestling are long-legged persons (on the basis of proportion of lower limb length to sitting body height – Manouvrier indicator). Applying the division on weight categories, only competitors of middle and light categories represent the length of lower limbs defined as average. Similarly like in the research of Marchocka and Skibińska [23], it is observed relative superiority of upper limb length over lower. Only within middle weight categories, clear superiority of elbow width over pelvis was disclosed. Superiority of elbow width over knee and the large differentiation of diameter features were also confirmed on the representatives of Poland in Greco-Roman wrestling (superiority of forearm diameter over shin diameter).

Numerous scientific research on the example of combat sports, mainly judo, confirm that the general direction of development of body build indicates at very muscular competitors with little value of slenderness components and with slightly bigger value of fat deposition [2,24,25].

Information gathered in result of analysis of internal proportions of body build of wrestlers significantly widens knowledge about features of their build. Among factors of body build of wrestlers, factor of stoutness is the most similar to comparative group (average value of factors in three weight categories is 0.32).We should remember however, that students of Warsaw Technical University are characterized by the highest indicators of biological development among the academic youth. The greatest predominance, with reference to comparative group, the wrestlers achieve in fat deposition factor, even though it is also diversified with regard to weight categories.

It corresponds with research on group of judokas in the world [25] – endomorphs level in the best competitors is kept within low limits of accepted standards, however it is characterized by very high values in competitors of the highest weight categories, where there is no upper limit of body mass and its big value may constitute an asset. Research conducted on a group of athletes confirm the fact that in those disciplines, where significant influence on the sport result has body mass, the dominant type of body build is pycnic type of build [26].

Łaska-Mierzejewska studies [3] on the material of sport games confirm significantly that tendency – athletes with high qualifications are characterized by very considerable superiority of one factor over others.

Interpersonal changeability of wrestlers indicates significant values (besides light category 0.65): middle categories 1.71, heavy 0.97. So significant predominance of one factor of body build upon another is exposed, what is characteristic for qualified competitors of some disciplines [3,27].

Natural indicators of somatic features within the limits of factors provide us with important information on specifics of body build of wrestlers. In the stoutness factor the predominance of forearm diameter (over shin) and elbow width are demonstrated. In the stoutness factor contribution of somatic features is more harmonious. Only slight predominance of upper limb length over lower in noted and low contribution of body height.

CONCLUSIONS

1. The important factor determining morphological differentiation of wrestlers are weight categories. The bigger the body mass the more distinct becomes change of body build into direction of body mass gain at the cost of loss of slenderness features. The greatest differences occur between heavy and light weight categories.

2. Wrestlers of heavy weight categories are characterized first of all by bigger body build. The characteristic feature is also big massiveness of skeleton (significant elbow, knee and pelvis width) and strong musculature (big diameters of forearm and shin). Relatively low value of body density is connected with the value fat deposition of wrestlers of heavy weight categories. They represent strong type of body build defined as stout /corpulent as well as significant overweight. Besides the competitors of heavy weight categories are long-legged.The relatively big values of pelvis width form average expressed male type of body build.

3. Body build of competitors of middle weight categories is the most similar to comparative group. Only forearm diameter significantly exceeds characteristic values for comparative group. Wrestlers of this group represent the strong body build type defined as athletic and right body mass. Besides they are classified as middle-length limbs with outstanding male body build type. They are also characterized by definitely lower values of body density with reference to light weight categories as well as the non training students.

4. Competitors of light weight categories are characterized by generally the smallest body build. The feature characteristic in their build is definitely small value of body height, knee width, upper limb length and shoulders width with reference to the comparative group. They represent the average type of body build or defined as athletic and right body mass. Wrestlers of light categories are classified as middle length limbs with strong stress on male body build.

5. Analysis of internal proportions of body build of wrestlers revealed essential differences of individual groups. General body size of competitors of light weight categories was caused by smaller than average intensity of length, average – stoutness and smaller than average fat deposition (2-4-3). In middle categories – proportionately smaller intensity of feature length, average – stoutness and dominating contribution of fat deposition factor (2-4-6). However in heavy weight it is smaller than average contribution of length, bigger than average – stoutness and average – fat deposition (3-5-4).

6. Proportions of external features show, that in all weight categories particularly strong muscle are on forearm and weak – on shin. In the features expressing stout-

ness of skeleton, only in wrestlers of light and middle weight categories occurs evident predominance of elbow width and non proportionate – in comparison with general size of the factor – small pelvis width.

Factor of length, in all weight categories, is the least varied. Only predominance upper limb length (particularly in heavy categories) over lower one and body height is observed.

REFERENCES:

1. Drozdowski Z: Antropometria w wychowaniu fizycznym. AWF w Poznaniu. Seria: Podręczniki Nr 24, 1998 [In Polish]

2. Jagiełło W, Kalina RM, Tkaczuk W: Morphological differentiation of judo competitors. In: J. Szopa, T.Gabryś (edit): Sport training in interdisciplinary scientific researches. Facultety of Menagement Technical University of Czestochowa. Chapter II, 200–6. Czestochowa 2004

3. Łaska-Mierzejewska T: Antropologia w sporcie i wychowaniu Fizycznym. Biblioteka Trenera. Centralny Ośrodek Sportu. Warszawa, 1999 [In Polish]

4. Garay AL, Levine L, Carter JEI: Genetic and Anthropological studies of Olympic Athletes, Academic Press, New York-San Francisco-Londyn, 1974

5. Leake CN, Carter JEL: Comparison of body composition and somatotype of trained female triathletes. Journal of Sports Sciences, 1991; 9(2): 125–35

6. Jagiełło W, Kalina R, Korobielnikow G: Morphological diversification of female judo athletes. Arch Budo, 2007, 3: 27–34

7. Jagiełło W, Tkaczuk W, Kruszewski A: Morfofunkcjonalne aspekty efektiwnosti sorewnowatelnoj dejatelnosti sportsmenok, specjalizirujuszczichsja w wolnoj borbe. Pedagogika, psychologia ta mediko-biologiczny problemy fizicznogo wichowania i sportu. Zb. nayk. pr. za Jermakowa SS (ed.), Charków HDADM (HHPI), 2004; 14: 93–104 [In Russian: English abstract]

8. Jagiełło W, Kruszewski A: Profil strojenia tela sbornoj komandy Polszi po klasiczeskoj borbe. Fiziczeskoje wospitanije studentów tworczeskoj specjalnostej. Naucznaja monografia Jermakowi SS (ed.), Charków: HGADI (HHPI), 2005; 8: 88–95 [In Russian: English abstract]

9. Jagiełło W, Polanowski B, Jagiełło M: Morfologiczne aspekty mistrzostwa sportowego kobiet trenujących szermierkę. In: Kuder A, Perkowski K, Śledziewski D (ed.): Proces doskonalenia treningu i walki sportowej. Tom 2, rozdział 2.6, 95–98. Warszawa, 2005 [In Polish]

10. Jagiełło M, Tkaczuk W, Jagiełło W: Konstitucionne aspekty sportiwnogo masterstwa kwalificirowannych tenisistok. Fiziczeskoje wospitanije studentów tworczeskich specjalnostej. Naucznaja monografia. Jermakowi SS (ed.), Charków: HGADI (HHPI) 2003; 2: 3–10 [In Russian: English abstract]

11. Jagiełło M, Jagiełło W: Somatic changes in polish representatives of tennis in the annual training period. In: Szopa J, T.Gabryś (eds.), Sport training in interdisciplinary scientific researches. Facultety of Menagement Technical University of Czestochowa. Chapter II, 193–200, Czestochowa 2004

12. Jagiełło W: Teoretiko-metodiczeskije osnowy sistemy mnogoletniej fiziczeskoj podgotowki junych dzjudoistów. Studia i Monografie. Akademia Wychowania Fizycznego Józefa Piłsudskiego w Warszawie, Nacjonalny Uniwersytet Wychowania Fizycznego i Sportu Ukrainy. Warszawa–Kijów, 2002 [In Russian]

13. Jagiełło W, Tkaczuk W, Jasiński T: Somatic development of children in the process of long-term training in judo. Education Physical Training Sport. Lithuanian Academy of Physical Education. Kaunas, 2004; 4(54): 59–65

14. Baxter-Jones ADG, Helms P, Maffulli N et al: Growth and development of male gymnasts, swimmers, soccer and tennis players: a longitudinal stady. Annals of Human Biology, 1995; 5: 381–94

15. Carter JL: The Somatotypes of Olympic Athletes. Presented Paper, 1978; 13

16. Brożek J, Keys A: The evaluation of leanness fatness in man. Norm and interrelationships. Brit J Nutr, 1949; 5: 194–206

17. Piechaczek H: Oznaczanie całkowitego tłuszczu ciała metodami densytometryczną i antropometryczną. Materiały i Prace Antropologiczne, 1975; 89: 3–48 [In Polish]

18. Piechaczek H, Lewandowska J, Orlicz B: Zmiany budowy ciała młodzieży akademickiej Politechniki Warszawskiej w okresie 35 lat. Wychowanie Fizyczne i Sport, 1996; 3: 3–14

19. Perkal J: O wskaźnikach antropologicznych. Przegląd Antropologiczny, 1953; 19: 209–11 [In Polish]

20. Milicerowa H: Zastosowanie wskaźników Perkala do charakterystyki budowy ciała bokserów. Materiały i Prace Antropologiczne, 1956; 20 [In Polish]

21. Matwiejew S, Jagiełło W: Judo – trening sportowy. Centralny Ośrodek Sportu. Biblioteka Trenera, Warszawa, 1997 [In Polish]

22. Jagiełło W" Wieloletni trening judoków. Biblioteka Trenera. Centralny Ośrodek Sportu, Warszawa, 2000 [In Polish]

23. Marchocka M, Skibińska A: Budowa ciała zapaśników w stylu wolnym. In: Zapasy. INKF, Seria Wyniki Badań. Warszawa, 1970; 19–38 [In Polish: English abstract]

24. Marchocka M, Nowacka E, Sikorki W: Specific body build of judo athletes depending on the fighting technique used. Biology of Sport, 1984; 3–4: 261–64

25. Kuźmicki S, Jagiełło W: Niektóre różnice i podobieństwa w budowie ciała judoków. In: Kalina RM, Jagiełło W (ed.), Wychowawcze i utilitarne aspekty sportów walki. Akademia Wychowania Fizycznego Józefa Piłsudskiego. Warszawa, 2000, 136–43 [In Polish]

26. Migasiewicz J: Zróżnicowanie dymorficzne wybranych cech morfologicznych kobiet i mężczyzn uprawiających rzut dyskiem. Wychowania Fizyczne i Sport, 1999; 3: 111–20 [In Polish]

27. Claessens A et al: Body structure, somatotype and motor fitness of top-class Belgia judoists and karateka: a comparative study. In: Kinanthropometry III. Ed. Reilly T, Watkins J, Borms T (eds.), London Spon, 1986; 53